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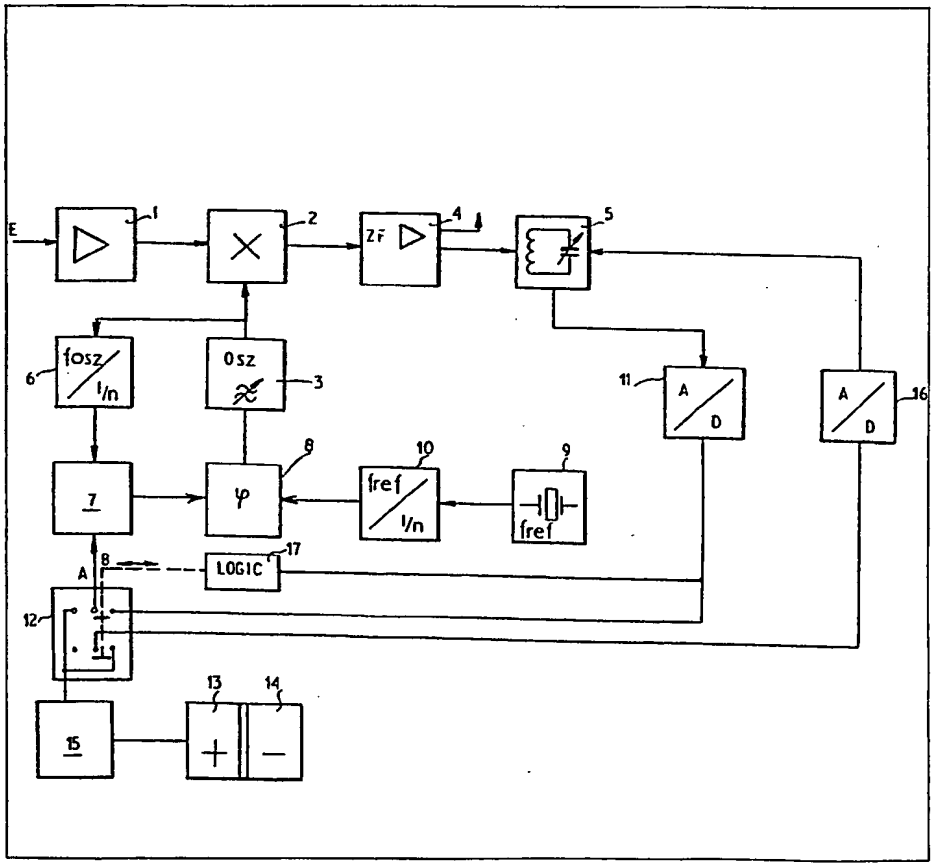
(71) Applicant
Loewe Opta GmbH
Postfach 220, 8640 Kronach, Federal Republic of Germany
(72) Inventor
Hilmar Missbach
(74) Agents
Dr. Walther Wolff & Co.

(54) **Receivers**

(57) In a receiver a settable frequency divider (6,7) divides the frequency of a voltage-controlled oscillator (3). The resultant frequency is compared in a phase comparison circuit (8) with a constant reference frequency an error voltage proportional to the phase deviation controls the oscillator (3). The oscillator frequency is furthermore additively mixed with the received frequency in a mixer circuit (2), which is followed by an intermediate frequency amplifier (4). A regulating circuit (5) including a frequency discriminator with a capacitance diode is provided for the purpose of automatic retuning and additional subjective detuning. It generates, in dependence on the deviation of the received frequency from the oscillator frequency as well as also through application of a voltage to the capacitance diode, a regulating voltage which after analog-digital conversion at 11 proportionally varies the set dividing ratio of the frequency divider (6,7). Retuning and search for a different station is facilitated by control keys 13, 14, a coder 15, a switch 12, a D/A converter 16 and a logic circuit 17 which shifts the frequency discriminator characteristics as well as vary the division ratio of 7 until the desired station is obtained.



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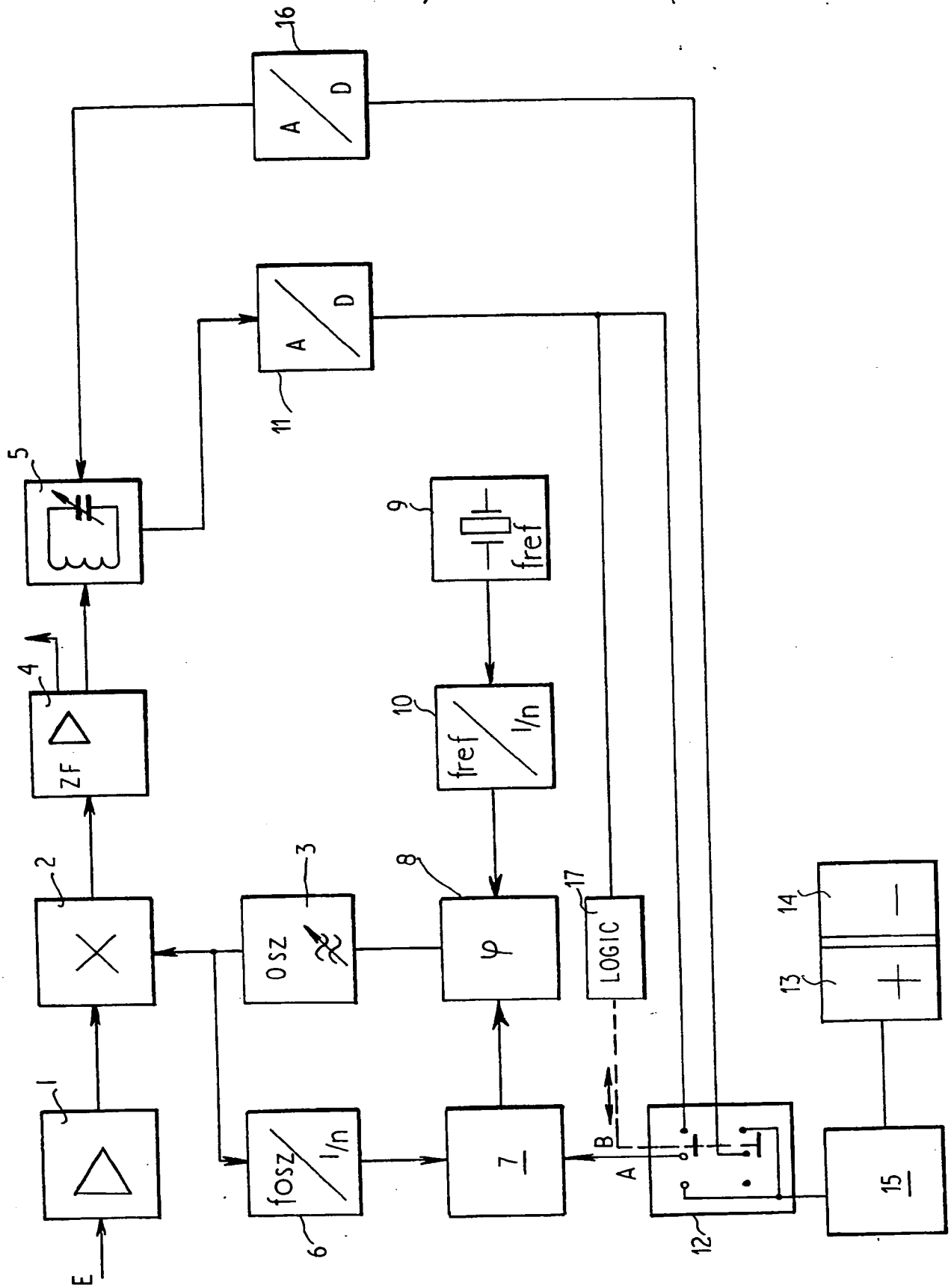

SPECIFICATION

Communications receiving equipment

The present invention relates to a communications receiving equipment including a receiver circuit with a digital frequency synthesiser.

In modern entertainment electronics, frequency synthesiser circuits are used to increasing degree for tuning of the receiving equipments to individual transmitters, in which circuits the oscillator frequency for the purpose of the tuning is divided by a programmable frequency divider and compared in a phase comparison stage with a constant reference frequency, wherein a voltage proportional to the phase deviation is obtained, which is applied as regulating voltage to the capacitance diode of the voltage-controlled oscillator. The thus regulated oscillator frequency is mixed additively or multiplicatively with the input frequency in a mixing stage according to the superimposition principle and the resultant intermediate frequency fed to the intermediate amplifier of the receiving equipment and processed in further receiver circuits. It is furthermore known in circuit arrangements without a frequency synthesiser to readjust the oscillator frequency by means of an automatic frequency correction regulating circuit. For this purpose, a part of the intermediate frequency is coupled out through a coupling coil and fed to a frequency discriminator. The voltage arising at the output of the frequency discriminator is applied to the frequency-determining component of the oscillator for direct regulation. The capacitance diodes employed as a rule vary their capacitances in dependence on the applied voltage and thereby make possible a detuning of the oscillator reasonant circuit. When a transmission channel is received, the discriminator voltage amounts to 0 volts so that the oscillator voltage is determined excluisvely by the preset value. On deviations, for example on drifting of the transmission channel or on drifting because of variation of the receiving components, a readjustment takes place until the voltage present at the output of the frequency discriminator has again reached 0 volts.

It is known from the house journal "Grundig Technische Informationen 2/77, pages 93 et seq." to apply the tuning voltage for a voltage-controlled oscillator directly from a voltage store which is charged up stepwise and to superimpose onto this a further regulating voltage from an AFC-circuit. Through displacement of the discriminator characteristic of the AFC-circuit, the voltage can in addition be arbitrarily varied in such a manner that a subjective tuning of a transmission channel takes place, whereby for example a television image given with optimum tuning is settable to be sharper or less sharp.

According to the present invention there is provided a communications receiving equipment comprising a voltage-controlled oscillator to provide an oscillator frequency, a frequency divider of settable dividing ratio to divide the oscillator frequency in a set dividing ratio, a phase comparison circuit to compare the divided frequency with a constant reference frequency, the voltage proportional to the phase deviation being fed as controlling voltage to the frequency-determining component of the oscillator, a regulating circuit including a frequency discriminator with a voltage-controlled capacitance diode to generate a regulating voltage in dependence on the deviation of the frequency of the received signal from the respectively corresponding oscillator frequency, and an analog-digital converter to convert the regulating voltage into a digital setting information signal which so decrements or increments the dividing ratio of the frequency divider proportional to the deviation as to automatically retune the oscillator frequency.

In a receiver circuit with frequency synthesiser a regulating circuit is provided with a frequency discriminator for the automatic retuning of the oscillator frequency, which for the subjective detuning of the reception frequency by incrementing or decrementing the dividing ratio of the frequency divider makes possible a detuning as well as a regulation to the newly set optimum frequency value. Furthermore, a receiver circuit with so-called channel forward switching, in which the frequency band is run through in predetermined channel raster by two fine tuning keys, by which transmission channels outside the predetermined channel raster are settable through incrementing or decjementing the dividing ratio of the frequency divider, enables the frequency divider as well as the regulating circuit to be settable through both the fine tuning keys in such a manner that the regulating circuit regulates optimally towards this detuned intermediate frequency on subjective detuning of a transmitter.

A circuit arrangement embodying the invention and provided for example in a television receiving equipment displays the characteristic property in the case of drifting transmission channels that, apart from transmission channels tuned exactly to picture carrier centre (38.9 Mega-Hertz) also subjectively detuned transmission channels are followed by a digital regulating circuit (AFC). This is attained through an interlinking of the AFC with the frequency synthesiser detuning in such a manner that the dividing ratio of the frequency divider is settable directly and also by the AFC after corresponding switching-on thereof, so that every subjectively set transmission channel can be tuned to through detuning of the resonant circuit with altered discriminator characteristic, while a regulation of the AFC takes place at the same time to this subjectively set transmission channel, for which purpose, parallel to the detuning through the frequency divider, the regulating circuit (AFC) is detuned through application of a voltage to a capacitance diode of the discriminator oscillator circuit.

It is possible through simple augmentation of a synthesiser settable in certain frequency steps, through simple detuning of the same by means of an AFC, to tune to any x-desired transmission channel lying between the fixed receiving channels, while it is secured at the same time that the AFC operates in respect of the newly set transmission channel departing from the optimum receiving frequency and regulates towards this subjectively set

transmission channel.

An embodiment of the present invention will now be more particularly described by way of example with reference to the accompanying drawing, which shows a block schematic diagram embodying the present invention.

Referring now to the drawing, the aerial input signal, which is amplified in an amplifier 1, lies at the input E of the circuit arrangement. The receiver frequency is mixed in a mixer stage 2 additively with the oscillator frequency of a voltage-controlled oscillator 3. The thus obtained intermediate frequency is fed for amplification to an intermediate frequency amplifier 4. A part of the amplified intermediate frequency is coupled out through a coupling coil or capacitive coupling and fed for automatic retuning of the oscillator frequency to a regulating circuit 5, in which a frequency discriminator with an oscillator circuit with a capacitance diode is contained. The intermediate frequency amplifier 4 is coupled to the signal evaluating circuits for the remainder of the amplified intermediate frequency. The signal path is characterised by an arrow and the following circuits are not described. The oscillator 3 is controlled through a constant preliminary divider 6, which divides the oscillator frequency in a constant ratio, and a programmable frequency divider 7, of which the dividing ratio is selectably settable by the operator. The dividing ratio of this frequency divider can for example be set through recall of certain digital stored setting information signals from a store, or be put in directly. In the latter case, the individual dividers are set directly through decade switching control. The oscillator frequency, divided by the frequency dividers 6 and 7, is compared in a phase comparison stage 8 with a constant reference frequency which is generated in a quartz oscillator 9 and divided in a constant ratio divider 10. The voltage resulting from the phase displacement is fed as regulating voltage to the oscillator 3 and through application to the capacitance diode of the oscillator, the oscillator circuit is varied in correspondence with the setting value. The dividing ratio of the frequency divider is fixedly settable not only through numeric inputs (not illustrated) or through recallable setting information signals stored in a store, but can also be varied by the regulating circuit 5 so that the digitally operating tuning circuit always remains fully effective even when a retuning must take place through the AFC in consequence of frequency drifts or subjective detunings. For this, the output of the frequency discriminator 5 is connected to an analog-digital converter 11, the output of which delivers digital setting information signals proportional to the deviation, which are conducted through an electronic change-over switch 12 in switch position B directly to the frequency divider 7. The discriminator of the regulating circuit 5 is in that case quantized, i.e. the well known S-curve is subdivided into a target value range, a range in excess of target value (positive) and a range of shortfall below target value, wherein target value and zero line in the ideal case are unity. When the voltage at the discriminator exceeds the target value, then the analog-digital converter has the effect that a corresponding number of steps with corresponding exceeding of individual threshold values is evaluated and a digital setting information signal, be it a series of individual pulses or a digital word, is delivered, which switches over the dividing ratio directly or varies it in steps.

It was presumed that the regulation always takes place towards a fixedly set transmission channel which is predetermined through input of the dividing ratio. It has now been shown in practice that an optimum setting to a transmission channel is possible only when a subjective retuning of the oscillator 3 takes place. It is necessary for this purpose that the frequency discriminator characteristic of the regulating circuit 5 is displaced. This takes place by actuation of control keys 13 and 14, by which a change in positive direction takes place through actuation of the key 13 and a change in negative direction through the key 14. Both the keys 13 and 14 deliver information signal magnitudes proportional to the actuation duration and which are coded in a coder 15 into a code which can be used for the direct setting of the dividing ratio of the frequency divider 7 as well as for conversion into an analog voltage for control of the capacitance diode of the oscillator circuit in the frequency discriminator of the regulating circuit 5. In order that this can take place, a second switch contact of the electronic changeover switch 12 is closed in switch position B so that digital information signals proportional to the duration of actuation are conducted to the digital-analog converter 16, which generates a correspondingly great setting voltage for the frequency-determining element (capacitance diode) of the oscillator circuit. Hereby, it is possible that the electronic search run as well as the retuning takes place through one and the same circuit through actuation of one and the same keys 13 and 14.

The setting process for the electronic search run is the following:

It is presumed that no transmission channel is received yet. By actuation of the keys 13 or 14 in positive or negative direction, which corresponds to the upper and lower part of the discriminator characteristic, the coded signal in switched setting B is switched through to the digital-analog converter. The capacitance of the capacitance diode of the oscillator circuit is varied proportionally to the setting magnitude so that the discriminator characteristic is displaced. The AFC-circuit is consequently detuned in non-linear steps, whereby a linear setting magnitude on exceeding the target value or on falling short of the target value of the discriminator characteristic is delivered through the analog-digital converter 11 to the frequency divider of which the dividing ratio, starting from a defined setting, is incremented on falling short of the zero line of the discriminator and decremented on exceeding it. It is now provided that a control logic 17 responds after a certain number of counting steps and switches over the electronic change-over switch, before attainment of the maximum of the frequency discriminator characteristic or on attain-

ment of the same, into switch position A so that both contacts are siwtched over. On continuous actuation of the keys 13 and 14, the dividing ratio of the frequency divider 7 is now set directly by the setting information signals coded in the coder 15. This takes place until a new transmission channel is received, whereby the frequency discriminator characteristic passes through the zero line. The analog-digital converter 11 in that case delivers the corresponding information signal which in turn causes the control logic 17 so to switch the electronic change-over switch 12 that the contacts in setting B leave the AFC-circuit switched on. In order that the AFC regulates towards this newly set transmission channel, it is necessary that, at the instant of the switch-over from switch position B to switch position A during the search run, a voltage is switched to the capacitance diode of the oscillator circuit of the frequency discriminator, which voltage resets the discriminator to its nominal position. Now, an automatic regulation sets in with the actuation of the keys 13 and 14, which takes place digitally. A superimposition of voltages is not given. The AFC acts on the frequency synthesiser, whereby the marked properties and advantages of the frequency synthesiser compared with voltage stores remain fully maintained.

A use of the described circuit arrangement is in television receiving equipments, since frequencies are allocated in a channel raster according to the CCIR-standard, an electronic search run with automatic frequency correction being assured likewise however in countries, in which allocated transmission frequencies are given outside this frequency raster. The same applies when a subjective detuning to an optimum picture becomes necessary in consequence of frequency drifts in different receiving areas. The arrangement is however also usable in conjunction with other communications receiving equipments.

On recall of a subjectively detuned transmission channel, it is necessary that, apart from the setting information signals to the frequency divider, also the data for the detuning of the discriminator oscillator circuit are stored and recalled. The latter store can be an analog store or a digital store, the recalled setting information signal of which is fed through the digital analog converter 16 to the capacitance diode of the oscillator circuit in the regulating circuit 5. The stores are not illustrated.

CLAIMS

1. A communications receiving equipment comprising a voltage-controlled oscillator to provide an oscillator frequency, a frequency divider of settable dividing ratio to divide the oscillator frequency in a set dividing ratio, a phase comparison circuit to compare the divided frequency with a constant reference frequency, the voltage proportional to the phase deviation being fed as controlling voltage to the frequency-determining component of the oscillator, a regulating circuit including a frequency discriminator with a voltage-controlled capacitance diode to generate a regulating voltage in dependence on the deviation of the frequency of the received signal from the respectively corresponding oscillator frequency, and an analog-digital converter to convert the regulating voltage into a digital setting information signal which so decrements or increments the dividing ratio of the frequency divider proportional to the deviation as to automatically retune the oscillator frequency.

2. A receiver circuit as claimed in claim 1, wherein the regulating circuit hs a frequency discriminator characteristic subdivded into the ranges of target value, excess over target value and shortfall below target value and wherein the analog-digital converter is arranged to deliver digital information signals for the altered setting of the dividing ratio in dependence on the target value deviation exceeding or falling short of certain threshold values.

3. A receiver circuit as claimed in either claim 1 or claim 2, wherein input keys are provided for setting the frequency divider or for recalling stored fixed dividing ratios or for initiation of an electronic search run, actuation of a setting key causing a voltage to be applied to the capacitance diode of the frequency discriminator to set the oscillator circuit to a oscillator frequency such that the discriminator curve is disposed in the nominal position.

4. A receiver circuit as claimed in claim 3, wherein a manually actuable analog value generator is provided to detune the oscillator circuit of the frequency discriminator by application of a voltage proportional to either time or setting after the setting of a dividing ratio and the analog-digital converter is connectable by switch means to the frequency divider.

5. A receiver circuit as claimed in either claim 3 or claim 4, comprising two fine tuning keys to respectively increment and decrement the frequency divider, the fine tuning keys being connected with digital circuits which deliver digital setting information signals proportional to the duration of actuation of the keys, and electronic change-over switch means arranged to be actuated by a control circuit in dependence on the frequency discriminator characteristic to connect the frequency divider with either the output of the analog-digital converter or directly with the fine tuning keys.

6. A receiver circuit as claimed in claim 5, wherein actuation of the fine tuning keys causes the oscillator circuit of the frequency discriminator to be detuned out of a nominal position in non-linear steps and the analog-digital converter is arranged to increment or decrement in linear steps in proportion to the detuning exceeding or falling short of the target value of the frequency divider, the electronic switch after running through a certain number of linear steps switches off the regulating circuit and switches on a control unit which generates a digital setting information signal proportional to the duration of actuation of the fine tuning keys thereby to set the dividing ratio while the oscillator circuit of the discriminator is simultaneously reset into the nominal position by application of a certain voltage to the capacitance diode, and the frequency divider is varied until a further target on the discriminator line is attained and the electronic change-over switch means under the

control of the responding control circuit causes the settable frequency divider to be disconnected from the fine tuning keys and to be connected to the regulating circuit.

7. A receiver circuit as claimed in claim 6, comprising a non-volatile store to recallably store the target value of the frequency divider and the digital setting value of the regulating circuit, said values being respectively applicable as setting information signal directly to the frequency divider and to the capacitance diode of the discriminator oscillator circuit on switching over to another transmission channel.

8. A receiver circuit as claimed in any one of claims 5 to 7, wherein the fine tuning keys are arranged to control a digital information signal transmitter to directly control the frequency divider and – when the regulating circuit is switched on – the information signal given by the transmitter is evaluated through a digital-analog converter to displace the discriminator line by application of the proportional voltage to the capacitance diode.

9. A communications receiving equipment substantially as hereinbefore described with reference to the accompanying drawing.

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